Design, Development and Optimization of Polyherbal Powder Shampoo using 3^2 Factorial Design

Abstract -

Objective: The goal was to create a polyherbal powder shampoo with natural components. We are aware that natural agents are safer and more effective than semi-synthetic and synthetic ones. Furthermore, those artificial components could harm or endanger human skin. In addition to encouraging hair development and strengthening and darkening hair, it removes sebum, grime, and dandruff. It does all of these things without harming or destroying hair, and it also serves as a conditioning agent. Based on the traditional system and scientific rationale with contemporary applications, the herbs amla, fenu Greek, green tea, bramhi, hibiscus, shikakai, and aritha have been chosen to create the polyherbal powder shampoo.

Methods: After being precisely weighed, the polyherbal powder shampoo was run through sieve number 100. Every component was thoroughly combined using constant trituration. After that, it was used for more research and kept in airtight containers. Organoleptic tests, general powder properties, physicochemical evaluation, ash and alcohol soluble extractives, moisture content determination, pH determination, cleaning action, foaming capacities, dirt dispersion, wetting time, and studies on the nature of hair after wash were all performed on all nine formulations (F1–F9).

Results: All the nine formulas (F1–F9) passes the test. Additionally, results within defined limitations were shown by general powder characteristics. The F6 formulation was shown to produce satisfactory results in physicochemical evaluations, pH determination, grease removal ability, foaming capacity, filth dispersion, wetting time, and hair type after washing.

Conclusion: The current study verified that the polyherbal powder shampoo was successfully prepared utilizing a mixing method without the need for additional excipients in varying quantities. Since it produced the best results, F6 is the optimized formula.

Keywords: Cosmeceuticals, Polyherbal powder shampoo, Organoleptic properties, dirt, cleaning action, foaming index

Introduction -

The Greek word "kosmos," which means "order,""decorate," and "ornament," and the word "cosmetic," which comes from the word "kosmetikos," which means "skilled in ordering or arranging"[1]. A product that cleans, beautifies, and enhances the appearance of the human body without altering its structure or functions is referred to as a cosmetic [2]. Powders, creams, pastes, gels, lotions, emulsions, perfumes, lipsticks, fingernail and toe nail polish, long-lasting waves, colored contact lenses, hair colors, hair sprays, gels, deodorants, baby products, bath oils, bubble baths, bath salts, soaps, shampoos, sunscreen, and more are all considered cosmetics [3].

A variety of natural components are employed in herbal cosmetics to deliver precise cosmetic advantages [4].

The essential component of human beauty is hair. Herbs were utilized for hair management, washing, and beauty in the ancient world. As a result, they used to color, shape, and trim their hair [5].Individuals maintain interest in and awareness of personal hygiene. Furthermore, maintaining personal hygiene is made simple by technological advancements [6]. Nowadays, people use shampoo to cleanse their hair and scalp [7]. The most popular hair products are shampoos. Herbal or synthetic ingredients can be found in shampoo. There are many different kinds of shampoos, including lotion shampoos, clear liquid shampoos, medicinal shampoos, powder shampoos, liquid herbal shampoos, and solid gel shampoos [8].Anti-dandruff shampoos can be used to get rid of dandruff, which is caused by fungi. The global market has a need for polyherbal formulations. Shampoos made from polyherbal ingredients are safe and have few negative effects. As a result, the market accepts it more [9].Zinc pyrithione, salicylic acid, imidazole derivatives, glycolic acid, steroids, sulfur, and coal tar derivatives are some of the chemicals used to treat dandruff. These drugs don't work well in therapeutic settings. After using it occasionally, dandruff recurs [10].The synthetic shampoo has good foaming properties since it contains cationic, anionic, and non-anionic surfactants. Therefore, every synthetic shampoo exhibits toxicity and causes eye discomfort.

It has been discovered that some compounds, including salts of calcium, magnesium, and sodium, are left on the hair shaft by surfactants. Consequently, the use of synthetic shampoo causes hair to become excessively dry. However, this issue can be avoided by using polyherbal shampoos [11,12].

A shampoo powder is considered optimal [13] when it:

- leaves hair smooth and manageable.
- removes dust particles and excess sebum from the scalp and hair thoroughly.
- is easy to remove when rinsed with water.
- gives hair a pleasant scent.
- cause no negative effects or skin or hair irritation.

Natural products have few adverse effects and are harmless. However, synthetic products are dangerous. Therefore, people choose herbal products. Products for synthetic hair may promote healthy hair development and a glossy appearance. When it is taken for long term causes damages to the hair which may even lead to baldness, premature hair graying and hair loss. EDTA, disodium EDTA, sodium sulfate, N-nitrosodiethanolamine, formaldehyde, and other harmful substances are found in some synthetic shampoos. Therefore, compared to polyherbal powder shampoo, synthetic shampoo damages hair more [14].

Shikakai and reetha are two herbal remedies that are safe to use for cleaning. Surfactants are present in shampoos and are distributed in an appropriate liquid, solid, or powder form. Therefore, it may cleanse the hair shaft of surface oil, grime, and skin debris without harming the user's hair. Similar to conventional shampoos, polyherbal shampoos are cosmetic formulations of traditional ayurvedic herbs intended to cleanse the hair and scalp. They are employed to remove pollutants from the environment, oils, dandruff, and filth, among other things[15].

This polyherbal composition has the advantage of using safe, natural ingredients. As a result, it has good stability and no negative consequences. Compared to store-bought shampoos, they are less damaging.

A variety of herbs and other substances, including Amla, Fenugreek, Green Tea, Brahmi, Hibiscus, Shikakai, and Aritha, are used in this inquiry.

Herbal products have few side effects and are reasonably priced. They are employed for both hair cleaning and hair management.[16]

MATERIALS AND METHODS OF PREPARATION OF HERBAL SHAMPOO:

To investigate the properties of hair care, various plant parts were chosen. The plants are Shikakai (fruits), Aritha (fruit), Brahmi (root), Amla (fruits), Fenugreek (leaves), and Green Tea (leaves). All of the necessary powders for these unrefined medications were gathered from the market of the nearby herbal pharmacy. After being precisely weighed, these powders were run through sieve number 100. It was then combined with constant trituration and kept in sealed jars.[17, 18]

Experimental Design of Polyherbal Powder Shampoo

The factorial design of Experiment 3^2 was used in this investigation. As per the extensive literature review, the amounts of green tea (X_2) and amla (X_1) were selected as independent variables in a 3^2-factorial design. Conversely, the percentage Foaming Index and cleaning action were considered dependent variables. As a result, the composition produced the intended cleaning action and foaming index percentage. The formulation made with several amla and green tea combinations was optimized. It was later assessed using the complete factorial design of Experiment 3^2.

Full factorial design

When a thorough examination of the elements' higher order interactions is required, this design can be helpful. Every feasible combination of factor levels is used for the runs. Full factorials are typically employed when a relatively small set of factors that are known to be significant are available or when gathering a high number of observations is practical, as the number of runs needed rises quickly as the number of factors increases. Effects are quantified as precisely as possible and more information is gathered with less effort.

The number of independent variables chosen determines how many experiments are needed for these investigations. For every trial, the response (Y) is measured.

$Y= b_0 + b_1 X_1 + b_2 X_2 + b_{12} X_1 X_2 + b_{11}X_{12} + b_{22} X_{22}$

Two independent factors were assessed at three levels each in the 32-full factorial design, and experimental trials were conducted for each of the nine potential combinations. The 32-full factorial design layout is displayed in Tables 1 and 2.
Two independent variables were selected as below:

X_1 = Amla (g)

X_2 = Green tea (g)

Table 1: Variables with coded and exact values for 3^2 full factorial design

Independent Variables	**Low**	**Medium**	**High**
Coded values	**-1**	**0**	**+1**
X_1 = Amla (g)	1.6	2.0	2.4
X_2 = Green tea (g)	0.8	1.0	1.2
Dependent Variables			
Y_1 = Cleaning action			
Y_2 = % Foam Index			

Table 2: Formulations

Ingredients	**F1**	**F2**	**F3**	**F4**	**F5**	**F6**	**F7**	**F8**	**F9**
Amla (Fruits)	1.6	2.0	2.4	1.6	2.0	2.4	1.6	2.0	2.4
Fenugreek (Leaves)	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
Green Tea (Leaves)	0.8	0.8	0.8	1.0	1.0	1.0	1.2	1.2	1.2
Brahmi (Root)	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
Hibiscus (Leaf and Flower)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Shikakai (Fruits)	2.8	2.4	2.0	2.6	2.2	1.8	2.4	2.0	1.6
Aritha (Fruits)	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
Total (g)	10	10	10	10	10	10	10	10	10

EVALUATION OF HERBAL POWDER SHAMPOO:

1. Organoleptic studies: Samples were selected at random for organoleptic evaluation studies based on factors such as color, taste and texture.[19, 20]

2. Characteristics of Powder: Particle size, angle of repose, bulk density, and tapped density are examples of general powder parameters that influence attributes like flow property. So,they are assessed. [21,22,23]

Particle Size: The microscope method was used to measure the herbal shampoo powder's particle size. Position the object in the center of the stage micrometer on the microscope and start focusing on lower power. Measure each particle's size in terms of eyepiece division after focusing the object. Choose two points, one on the left and one on the right. Calibration factors can be used for calculations.[17, 24]

Calibration factor = Number of stage divisions/ Number of eye piece divisions *10

Angle of Repose: Over a glass plate, a clamp-on ring support kept a glass funnel in place. A tiny lab jack held the glass plate. About 10 grams of the powder were added to the funnel while the thumb was used to obstruct the funnel's aperture. The lab jack was adjusted to lower the plate while keeping a space of roughly 2 cm between the top of the powder pile and the bottom of the funnel stem as the thumb was removed. A protractor was used to measure the heap's angle to the horizontal plane after the powder was removed from the funnel. A ruler was used to measure the height and radius. Thus, the following formula was used to estimate the angle of repose.The angle of repose was thus estimated by the following formula. It is expressed in g/cm^3.[17,25]

$$\theta = \tan^{-1} (h/r)$$

Where,

θ = Angle of repose

h = Height of the pile formed

r = Radius of the base of pile

Bulk Density: The ratio of an untapped powder sample's mass to volume, including the contribution of the inter-particulate void volume, is known as the powder's bulk destiny. As a result, the bulk density is influenced by the powder's particle density as well as its spatial organization. The unit of measurement for bulk density is g/cm3. After obtaining a 100 ml graduated cylinder, the necessary quantity of herbal shampoo powders (F1–F9) was added. Bulk density was computed once this was moved to a bulk density instrument. It is a crucial characteristic for packaging and consistency in the product's bulk.[26]

Bulk Density = Mass of powder/ Bulk volume of the powder

Tapped Density: A 100 ml graduated cylinder was filled with the necessary quantity of herbal shampoo powders (F1–F9), and the cylinder was tapped for two minutes until there was minimal volume change.[27, 28]

It is expressed in g/cm^3. The tapped density is calculated by using the following formula:

Tapped density = Mass of the powder/ Tapped volume of the powder

3. Physicochemical Analysis:

Extractive values:

Determination of water soluble extractive:

In a 250 ml conical flask, 4g of dried herbal shampoo powder was weighed, macerated with 100ml of chloroform for 24 hours, shaking frequently for 6 hours, and then left to stand for 18 hours. Fill a 50 ml cylinder with the filter. Transfer 25 milliliters of the filtrate to a thin, weighted porcelain dish, which is used to determine the ash values, once enough filtrate has accumulated. Dry on the water bath and finish drying in an oven set to 105°C for six hours. After 30 minutes of cooling in desiccators, weigh right away.[18, 19] Determine the extractive percentage in relation to air-dried shampoo powders (F1-F9).

Water soluble extractive value of the sample = 80*%

Ash value:

Assessment of the polyherbal shampoo powder's quality and purity.

Determination of total ash

A thin, flat porcelain dish or a silica crucible that had been tarred was weighed and set on fire. A dish was filled with roughly 2g of the herbal shampoo powder composition (F1-F9) after it had been weighed. The dish is supported by a pipe-clay triangle that is set on a retort stand ring. Using a burner, heat the dish about 7 cm above the flame until the vapors nearly stop evolving. Then, lower the dish and determine the percentage of total ash in relation to the air-dried shampoo powders.[18, 29]

Determination of acid insoluble ash:

Wash the ash from the total ash plate into a 100 ml beaker after calculating the total ash value with 25 ml of diluted hydrochloric acid. For five minutes, place mere gauze over a Bunsen flame and bring it to a boil. Use ash-free filter paper to filter, then rinse the residue with hot water twice. Set a crucible on fire, let it cool, and then weigh it. Place residue and filter paper in a crucible and heat it gradually until no more fumes are released, then more vigorously until all of the carbon has been eliminated. Use desiccators to cool.[18,31] Using the air-dried herbal shampoo powders (F1-F9) as a guide, weigh the residue and compute the acid insoluble ash.

Moisture content determination:

In a tarred evaporating dish, 10g of herbal shampoo powder formulations (F1–F9) were maintained at 105° C in a hot air oven. Until a steady weight was achieved, the weight loss was noted every fifteen minutes.[32, 33]

pH:

10 ml of water were used to dissolve one gram of each of the herbal shampoo powder formulations (F1–F9). They used a digital pH to monitor their pH. [34]

Skin/eye irritation test:

The herbal powder shampoo has no negative effects on the eyes or skin. The lack of artificial surfactants is the cause of this. The majority of synthetic surfactants cause corneal irritation and eyelid inflammation. However, natural ingredients were included in this polyherbal powder shampoo formulation. Therefore, it has no negative effects on the skin or eyes. [35]

Cleaning action:

After soaking 2g of wool in grease, it was put in a flask with 200 ml of water and 1g of each of the polyherbal powder shampoo formulations (F1–F9). The flask was then shaken for 4 minutes. After removing the solution, the sample was extracted, dried, and weighed. It was calculated how much grease was eliminated. [36]

Foaming capacity:

50ml of water was poured to a 250ml graduated cylinder containing 2g of each herbal shampoo powder formulation (F1–F9), and the mixture was shaken five to ten times. Following a one-minute shake, the foaming capacities of all nine formulations (F1-F9) were measured, as was the percentage of foaming capacities during a 60-minute period. [37]

Dirt dispersion:

10 ml of distilled water were placed in a big test tube, and two drops of each of the 1% herbal shampoo powder formulations (F1–F9) were added. After adding a drop of Indian ink, the test tubes were shaken and sealed. It was judged that there was none, moderate, or substantial ink in the foam. [38]

Wetting time:

A canvas was taken and cut into 1 inch diameter discs. The discs were floated on the surface of each formulation (F1-F9) of 1% herbal shampoo powder solution and time was noted. The time required for the disc to begin sink was measured accurately and noted as wetting time.[39]

RESULTS:

Organoleptic properties:

All of the herbal shampoo powders' visual inspection findings were noted and assessed for color, taste, odor, appearance, flow characteristics, and texture. They exhibit a noticeable hue shift to some extent. Table 3 presented the findings.

TABLE 3: EVALUATION OF ORGANOLEPTIC PROPERTIES

Evaluation parameters	Colour	Odour	Texture
F1	Faint Brown	Characteristic	Fine and smooth
F2	Faint Brown	Characteristic	Fine and smooth
F3	Brown	Characteristic	Fine and smooth
F4	Faint Brown	Characteristic	Fine and smooth
F5	Faint Brown	Characteristic	Fine and smooth
F6	Brown	Characteristic	Fine and smooth
F7	Faint Brown	Characteristic	Fine and smooth
F8	Faint Brown	Characteristic	Fine and smooth
F9	Faint Brown	Characteristic	Fine and smooth

Characteristics of Powder:

Results were obtained for bulk density, tapped density, particle size, and angle of repose. Every herbal shampoo powder exhibits outcomes within the specified ranges for the corresponding assessment criteria. Table 4 presented the findings.

TABLE 4: THE CHARACTERISTICS OF POWDER

Evaluation parameters	F1	F2	F3	F4	F5	F6	F7	F8	F9
Particle size (μm)	1-10	1-10	1-10	1-10	1-10	1-10	1-10	1-10	1-10
Angle of repose (^{0})	41.98	41.02	39.35	39.69	38.56	37.50	43.10	41.96	40.12
Bulk density (g/cm^3)	0.36	0.39	0.41	0.38	0.41	0.46	0.40	0.43	0.47
Tapped density (g/cm^3)	0.49	0.55	0.53	0.54	0.53	0.57	0.59	0.61	0.65

Physicochemical Analysis: The results of extractive values, ash values and moisture content were reported in Table 4.

Determination of pH:

All the formulations (F1-F9) of herbal shampoo powders were acid balanced and all formulations showed slightly acidic pH which may not cause damage to hairs. The results were reported in Table 5.

TABLE 5: THE PHYSICOCHEMICAL ANALYSIS STUDIES

Evaluation Parameters	F1	F2	F3	F4	F5	F6	F7	F8	F9
Extractive values: Water soluble (%w/w)	20.2	32	22	18.8	20.2	32	22	18.8	18.8
Ash value: Total ash (%w/w)	17.8	17.2	16.8	19.8	17.8	17.2	16.8	19.8	19.8
Acid insoluble ash (%w/w)	5.4	4.2	4.6	7	5.4	4.2	4.6	7	7

Moisture content: (%w/w)	91.65	89	89.85	89.4	91.65	89	89.85	89.4	89.4
pH	5.6	5.5	5.4	5.4	5.6	5.5	5.4	5.8	5.4

Cleaning action:

Since a shampoo powder's main function is cleaning, the cleaning action of wool in grease was evaluated. The results show that the five batches of herbal shampoo powders produced differed significantly in how much grease they were able to remove. The F1–F9 formulas' cleaning properties were noted. When compared to other formulations, F6 formulations demonstrated superior grease removal capabilities. Table 6 reported these.

TABLE 6: THE CLEANING ACTIVITY EVALUATION PARAMETERS

Evaluation Parameter	**F1**	**F2**	**F3**	**F4**	**F5**	**F6**	**F7**	**F8**	**F9**
Cleaning action (%)	78	83	86	91	95	98	79	84	89

Foaming capacity:

In distilled water, the foaming properties of the four herbal shampoo powder compositions are similar. After one minute of shaking, the total volume of foam from the herbal shampoo powders ranged from mild to good. Tables 7 and 8 present the average % foaming capacities for F1-F9 formulations recorded over a 60-minute period.

TABLE 7: THE FOAMING CAPACITIES OF ALL FORMULATIONS

Evaluation Parameter	**F1**	**F2**	**F3**	**F4**	**F5**	**F6**	**F7**	**F8**	**F9**
Foaming capacity (%)	Good foam	Good foam	Mild foam	Good foam	Good foam	Good foam	Mild foam	Good foam	Good foam

TABLE 8: THE % FOAMING CAPACITY OF POLYHERBAL POWDER SHAMPOO

Time (Minutes)	**Foaming Capacity**								
	F1	**F2**	**F3**	**F4**	**F5**	**F6**	**F7**	**F8**	**F9**
0	126	132	141	148	155	156	159	168	183
5	122	130	139	144	152	153	157	166	180
30	119	126	134	138	147	149	154	163	176
60	113	120	130	134	142	146	150	159	173
Average foaming capacity	120	127	136	141	149	151	155	164	178

Dirt dispersion:

Shampoo powders are regarded as being of low quality if they concentrate the ink in the foam. It will be challenging to rinse away any filth that remains in the foam. The amount of ink in the foam of the polyherbal powder shampoo formulations F1 through F9 was assessed. It was discovered that it varied from light to moderate. Table 9 presented the findings.

TABLE 9: THE DIRT DISPERSION PARAMETERS OF ALL THE FOUR FORMULATIONS

Evaluation Parameter	**F1**	**F2**	**F3**	**F4**	**F5**	**F6**	**F7**	**F8**	**F9**
Dirt dispersion	Light	Light	Light	Moderate	Moderate	Moderate	Light	Light	Light

Wetting time:

A substance's wetting time depends on its concentration. The F1–F9 formulas' wetting times were noted. In contrast to the other three formulations, the F1 formulation had a shorter wetting time. Table 10 presented the findings.

TABLE 10: THE EVALUATION PARAMETERS OF WETTING TIME OF ALL THE FOUR FORMULATIONS

Evaluation Parameter	**F1**	**F2**	**F3**	**F4**	**F5**	**F6**	**F7**	**F8**	**F9**
Wetting time (min)	2	2	2	2	2	2	3	3	3
(sec)	10	24	35	41	48	56	15	22	31

Nature of hair after wash:

Volunteers were given polyherbal powder shampoo formulations (F1–F9) to test the nature of their hair after washing, and the results showed that the hair was soft and manageable.

Statistical Analysis

Analysis was done on the 32 full factorial design results. Utilizing statistical design to optimize the formulation yielded a significant amount of information. ANOVA, lack of fit, and coefficient of determination (R2) were used to confirm that the quadratic model, to which all of the responses were fitted, was compatible. Every response should be related to every other response in order to maximize the responses, and each response must be required to be in the most supporting zone in order to eliminate prejudice. Numerous studies validated the use of the desirability function to maximize the number of answers [40, 41]. Multiple linear regression analysis was used to statistically analyze the factorial design batches. As dependent variables, the Cleaning action (Y1) and the Foaming Index (Y2) were used.

Table 11 displays the responses, Cleaning action (Y1) and Foaming Index (Y2), to the transformed component derived from the full model equation. After taking into account the amount of the coefficient and the mathematical sign it conveys (i.e., positive or negative), inferences can be drawn from the polynomial equations. Version 13 of Design of Expert was used to examine the data. The cleaning action (Y1) and foaming index (Y2) R2 values were 0.9956 and 0.997, respectively, suggesting that the dependent and independent variables were well correlated. Developing simplified models was unnecessary because the response variables were significant ($P < 0.05$). The full model kept the words with $P<0.05$ since they were deemed statistically significant.

According to the ANOVA results, the cleaning action (Y1) and foaming index (Y2) F values were, respectively, 134.76 and 1945.41.The factors chosen have demonstrated significant effects because the calculated F values for each dependent variable were higher than the tabulated values. Both factors showed statistically significant effects on all dependent variables, according to the multiple regression analysis results, with $p <0.05$ (Table 11).

Table 11: Summary of regression analysis of the responses

Quadratic Model	**R^2**	**Adjusted R^2**	**SD**	**Adequate Precision**	**p-value**
Cleaning action	0.9956	0.9882	0.7454	33.1372	< 0.0010
Foaming Index	0.9970	0.9992	0.5358	131.826	< 0.0001

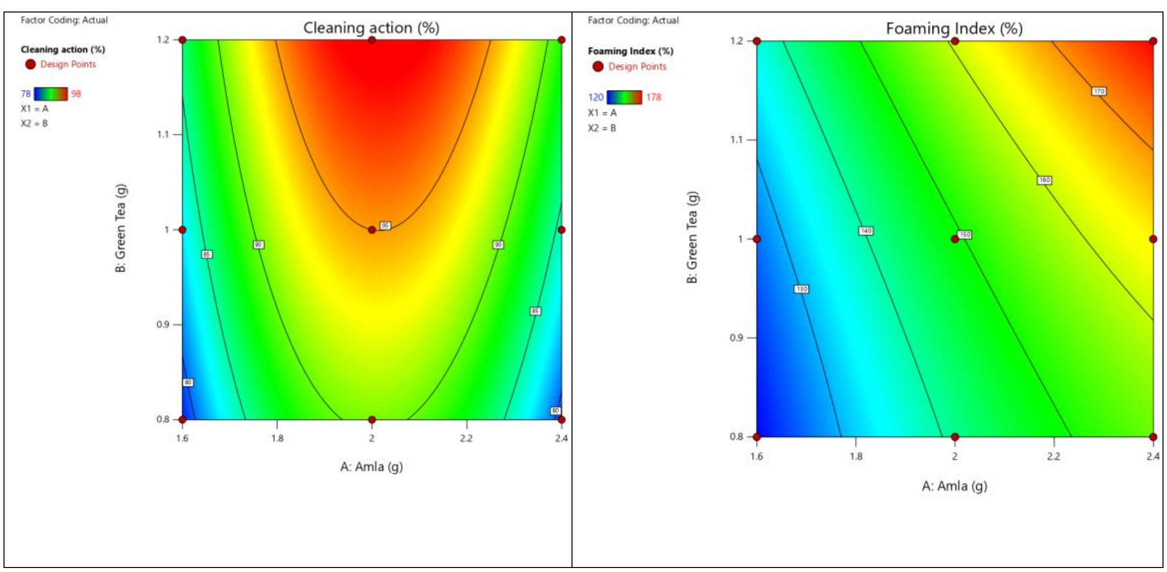

Fig. 1: 2D Response surface contour plot showing effect of Amla and Green tea

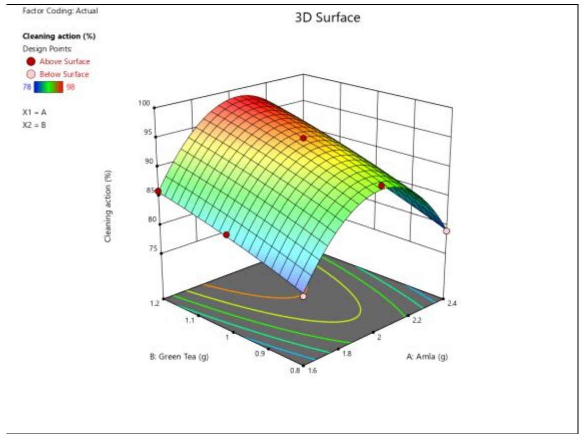

Fig. 2: 3D Response surface showing effect of Amla and Green tea on Cleaning action

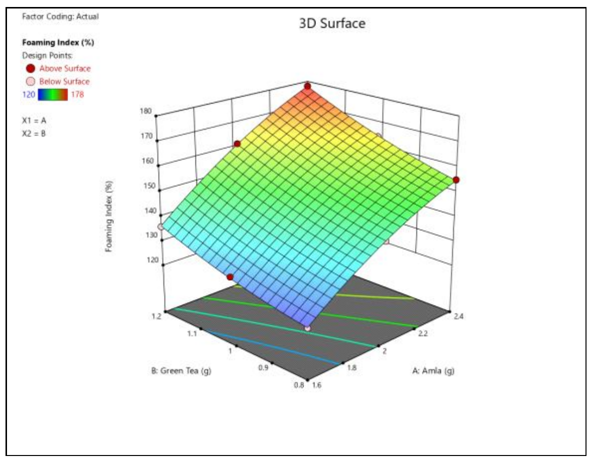

Fig. 3: 3D Response surface showing effect of Amla and Green tea on Foaming Index

Full and reduced model for Cleaning Action

As the concentration of Amla (X1) increased, a commensurate decrease in cleaning action was seen, according to the contour plot and 3D response surface graph for cleaning action shown in Figures 1 and 2, respectively. Furthermore, the findings also showed that, in comparison to green tea, the impact of amla (X1) was less significant. Regression analysis revealed that X1 and X2 were important model terms that influenced the polyherbal powder shampoo's efficacy. There was no evidence of interaction or non-linearity.

The P values for the significant levels of the coefficients b2, b12, and b22 for cleaning action were determined to be 0.0714, 0.2722, and 0.4128, respectively. Therefore, in order to create a simplified model, it was left out of the full model. At $P < 0.05$, the coefficients b0, b1, and b11 were determined to be significant. They were therefore kept in the scaled-down model.

The reduced model for cleaning action was:

Cleaning action = +95 + 0.83*X_1 + 4.17X_2 -11.50*X^2_1

Full and reduced model for Foaming Index

The contour plot and 3D response surface graph for the Foaming Index were shown in Figures 1 and 3, respectively, and they demonstrated that when Green tea concentrations increased, so did the Foaming Index. Furthermore, it can be inferred from the regression coefficient values of both factors that the Foaming index seemed to rise more as the quantity of green tea increased. Non-linearity and interaction were noted.
The P values for the significant levels of the co-efficients b12, b11, and b22 for the Foaming index were 0.0073, 0.0023, and 0.0168, respectively. Therefore, in order to create a simplified model, it was left out of the full model.The coefficients b_0, b_1 and b_2 were found to be significant at $P < 0.0001$. Hence, they were retained in the reduced model.
The reduced model for Foaming Index was:

Foaming Index = +149.11 + 19.0*X_1 + 9.83*X_2

Validation by Check point batch

To verify the accuracy of the response surface plot and equation produced by multiple regression analysis, a check point batch was created. Design Expert 13's required range of evaluation parameters was added to create an overlay plot. In Figure 4, the overlay plot is displayed. The overlay plot's yellow area indicated the ideal concentration range for the intended outcome. Amla (X1) and green tea (X2) concentrations were measured in an overlay plot to create a batch, and the generated check point batch was used to assess the actual responses. The overlay plot revealed the ideal concentration that produced the best outcome. The values that were practically attained were more in line with the ones that were projected. As a result, it supported the design's validation.

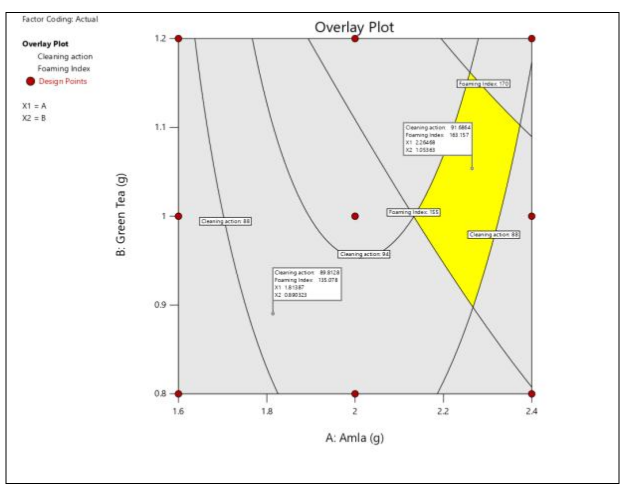

Fig 4: Overlay plot of Check point batch

CONCLUSION:

The polyherbal powder shampoo were successfully prepared, optimized and evaluated using Design Expert software by 3^2 full factorial design. The present investigation showed quick Cleaning action of the polyherbal powder shampoo . Amla and Green tea were used as cleaning and foaming agents respectively. These formulations were evaluated for the parameters like organoleptic properties, powder characteristics, pH, physiochemical analysis,cleaning action, foaming index, dirt dispersion, wetting time . On the basis of preliminary results, the amount of Amla (X_1) and the amount of Green tea (X_2) were selected as independent variables in 3^2 full factorial design, while Cleaning action and Foaming Index were taken as dependent variables. Multiple linear regression analysis, ANOVA and graphical representation of the influence of factor by contour plots and 3D response surface graphs were performed using Demo version of Design Expert 13. Check point batch was prepared to validate the evolved model. Batch F6 was selected as an optimized batch.

Disclaimer (Artificial intelligence)

We hereby declared that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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